EXHIBIT 11

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

TQ DELTA, LLC, **Plaintiff,** v.	§ § § § §	**JURY TRIAL DEMANDED**
COMMSCOPE HOLDING COMPANY, INC., COMMSCOPE INC., ARRIS INTERNATIONAL LIMITED, ARRIS GLOBAL LTD., ARRIS US HOLDINGS, INC., ARRIS SOLUTIONS, INC., ARRIS TECHNOLOGY, INC., and ARRIS ENTERPRISES, LLC,	§ § § § § § § §	**Civil Action 2:21-cv-310-JRG** **(Lead Case)**
NOKIA CORP., NOKIA SOLUTIONS AND NETWORKS OY, and NOKIA OF AMERICA CORP. **Defendants.**	§ § § § §	**Civil Action No. 2:21-cv-309-JRG** **(Member Case)**

DECLARATION OF DR. MADISETTI IN SUPPORT OF PLANTIFF'S OPENING CLAIM CONSTRUCTION BRIEF FOR PATENT FAMILIES 1, 4, AND 6

I, Vijay Madisetti, hereby declare under penalty of perjury:

1. I have been retained by TQ Delta, LLC ("TQD") as an expert in connection with the above-captioned litigation to offer opinions regarding claim construction for the following patents belonging to TQ Delta ("the Asserted Patents:"):

Family 1

- U.S. Patent No. 7,570,686 ("the '686 patent")

Family 4

- U.S. Patent No. 8,090,008 ("the '008 patent")

Family 6

- U.S. Patent No. 10,567,112 ("the '112 patent")
- U.S. Patent No. 8,462,835 ("the '835 patent")
- U.S. Patent No. 8,594,162 ("the '162 patent")

2. I submit this declaration in support of TQD's Opening Claim Construction Brief. I have been asked to provide my opinions as to how one of ordinary skill in the art would understand certain claim terms appearing in the Family 1, 4 and 6 Patents.

3. I am being compensated as an independent consultant in this matter at the rate of $500 per hour for analysis of documents and preparation of any declaration or report. This compensation is not dependent on my opinions or testimony, or the outcome of this litigation.

I. QUALIFICATIONS AND BACKGROUND

4. I received my Bachelor of Technology (Honors) in Electronics and Electrical Communication Engineering at the Indian Institute of Technology (IIT) in Kharagpur, India in 1984. I obtained my Ph.D. in Electrical Engineering and Computer Science at the University of California, Berkeley, in 1989. I received the Demetri Angelakos Outstanding Graduate Student

Award from the University of California, Berkeley and the IEEE/ACM Ira M. Kay Memorial Paper Prize in 1989.

5. I am a tenured Professor in Electrical and Computer Engineering at the Georgia Institute of Technology ("Georgia Tech"). I am knowledgeable and familiar with wireless communications, microprocessor architecture, hardware, RF, cellular networks, ASIC design, computer engineering, embedded systems, digital signal processing, and associated software and firmware design for wireless and telecommunications terminals and base stations. I have created and taught undergraduate and graduate courses in hardware and software design for signal processing and wireless communication circuits at Georgia Tech for the past twenty years. Additionally, I have been active in the areas of wireless communications, digital signal processing, integrated circuit design (analog & digital), software engineering, system-level design methodologies and tools, and software systems. I have been the principal investigator ("PI") or co-PI in several active research programs in these areas, including DARPA's Rapid Prototyping of Application Specific Signal Processors, the State of Georgia's Yamacraw Initiative, the United States Army's Federated Sensors Laboratory Program, and the United States Air Force Electronics Parts Obsolescence Initiative. I have received an IBM Faculty Award and NSF's Research Initiation Award.

6. I have designed several specialized computer and communication systems over the past two decades at Georgia Tech for tasks such as wireless audio and video processing and protocol processing for portable platforms, such as cell phones and PDAs. I have worked on designing systems that are efficient from the perspective of performance, size, weight, area, and thermal considerations. I have developed courses and classes for the industry on these topics, and many of my lectures in advanced computer system design, developed under the sponsorship of the

United States Department of Defense in the late 1990s, are available for educational use at "http://www.eda.org/rassp" and have been used by several U.S. and international universities as part of their course work. Some of my recent publications in the area of design of wireless communications systems and associated protocols are listed in Exhibit A. I have graduated more than 20 Ph.D. students that now work as professors or in technical positions around the world.

7. I have studied a variety of signal processing and communications technologies with respect to digital subscriber loops since the early 1990s. In "Multilevel Range/Next Performance of Digital Subscriber Loops", IEE Proceedings, Vol 136, April 1989, I discussed results on range performance of multilevel signal schemes in the presence of Near End Crosstalk (NEXT) over digital subscriber loops. I was part of the team from University of California Berkeley that submitted a proposal for standardization to the T1D1 as noted below:

BRAND, G.H., LEE, E.A., LIN, N.S., HODGES, D.A., MADISETTI, V.K., and MESSERSCHMITT, D.G.: 'Comparison of line codes with optimal DFE design'. Standard for ISDN basic access interface for applications at the network side of NT1, Layer 1 Specifications, 24th January 1986, Contribution T1D1.3/86-018

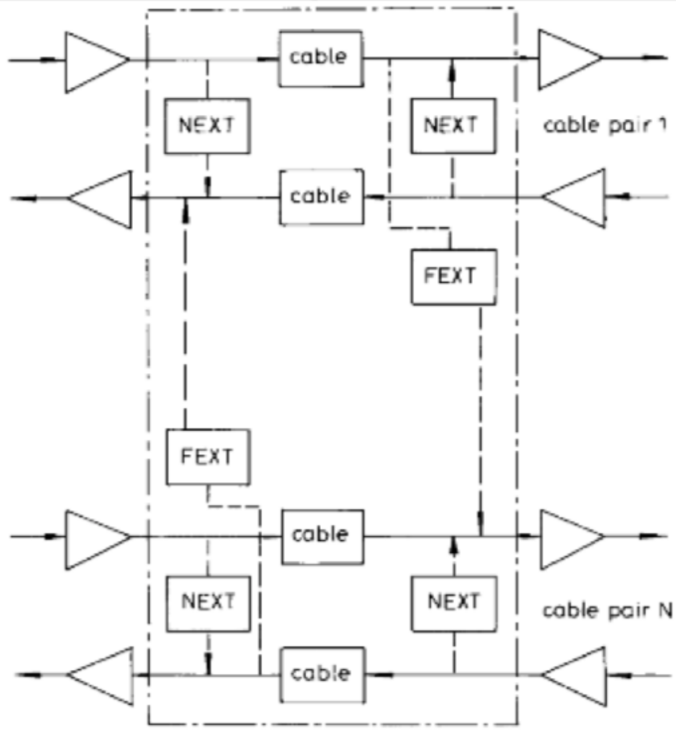


Fig. 1 *Crosstalk coupling model*

8. I have been an active consultant to industry and various research laboratories (including Massachusetts Institute of Technology Lincoln Labs and Johns Hopkins University Applied Physics Laboratory). My consulting work for MIT Lincoln Labs involved high resolution imaging for defense applications, where I worked in the area of prototyping complex and specialized computing systems. My consulting work for the Johns Hopkins Applied Physics Lab ("APL") mainly involved localization of objects in image fields, where I worked on identifying targets in video and other sensor fields and identifying computer architectures and circuits for power and space-efficient designs.

9. I have founded three companies in the areas of embedded software, military

chipsets involving imaging technology, and wireless communications. I have supervised the Ph.D. dissertations of over twenty engineers in the areas of computer engineering, signal processing, communications, rapid prototyping, and system-level design methodology, of which five have resulted in thesis prizes or paper awards. The first of the companies I founded, VP Technologies, offers products in the area of semiconductor integrated circuits, including building computing systems for imaging systems for avionics electronics for the United States Air Force and the US Navy. I remain a director of VP Technologies. The second of these companies, Soft Networks, LLC, offers software for multimedia and wireless computing platforms, including the development of a set-top box for Intel that decodes MPEG-2 video streams, wireless protocol stacks, and imaging codecs for multimedia phones. The third of these companies, Elastic Video, uses region of interest-based video encoding or decoding for capturing high quality video at very low bit rates, with primary application for wireless video systems.

10. I have authored more than sixty refereed journal publications and around forty peer reviewed conference publications. I have been active in research in the area of wireless and mobile communications and some of my recent peer-reviewed publications in this area include: (i) Mustafa Turkboylari & Vijay K. Madisetti, Effect of Handoff Delay on the System Performance of TDMA Cellular Systems, Proceedings of the Fourth IEEE Conference on Mobile and Wireless Communications Network 411-15 (Sept. 9-11, 2002); (ii) Loran A. Jatunov & Vijay K. Madisetti, Computationally-Efficient SNR Estimation for Bandlimited Wideband CDMA Systems, 5 IEEE Transactions on Wireless Communications, no. 12 (2006) at 3480-91; and (iii) Nimish Radio, Ying Zhang, Mallik Tatipamula & Vijay K. Madisetti, Next Generation Applications on Cellular Networks: Trends, Challenges, and Solutions, 100 Proceedings of the IEEE, no. 4 (April 2012) at 841-54. I have extensive experience analyzing, designing, and testing systems based on 3GPP

Technical Specifications, including specifications describing WCDMA and HSDPA technologies. I have been active in the area of location-based services and wireless localization techniques since the mid-1990s, and have authored several papers on location-based services, including, Vijay K. Madisetti et al., Mobile Fleet Application Using SOAP and System on Devices (SyD) Middleware Technologies, Communications, Internet, and Information Technology (2002) at 426-31. I have served as associate editor or on the editorial board for technical journals, including IEEE Transactions on Circuits & Systems II, International Journal in Computer Simulation, and International Journal in VLSI Signal Processing.

11. I have authored or co-authored several books, including VLSI Digital Signal Processors (IEEE Press 1995) and the Digital Signal Processing Handbook (CRC Press, 1998, 2010). I co-authored Quick-Turnaround ASIC Design in VHDL (Kluwer Academic Press 1996) and Platform-Centric Approach to System-on-Chip (SoC) Design (Springer 2004). I am also the editor of several books, including the three-volume DSP Handbook set: Volume 1: Digital Signal Processing Fundamentals, Volume 2: Video, Speech, and Audio Signal Processing and Associated Standards, and Volume 3: Wireless, Networking, Radar, Sensory Array Processing, and Nonlinear Signal Processing, published in 2010 by CRC Press, Boca Raton, Florida. More recently I have authored Cloud Computing (2014, CreateSpace Press), and Internet of Things (2014, CreateSpace), and the book, Cloud Computing, was nominated as a Notable Book of 2014 by the Association of Computing Machinery (ACM) in July 2015.

12. My experience is relevant to this case. I have been working in the area of communications and signal processing, since the early 1980s. I have performed research in the area of multicarrier communications and signal processing for multicarrier communication systems.

13. I have been elected a Fellow of the IEEE, for contributions to embedded computing systems. The Fellow is the highest grade of membership of the IEEE, a world professional body consisting of over 300,000 electrical and electronics engineers, with only one-tenth of one percent (0.1%) of the IEEE membership being elected to the Fellow grade each year. Election to Fellow is based upon votes cast by existing Fellows in IEEE. I have also been awarded the 2006 Frederick Emmons Terman Medal by the American Society of Engineering Education for contributions to Electrical Engineering, including authoring a widely used textbook in the design of VLSI digital signal processors. I was awarded VHDL International Best PhD Dissertation Advisor Award in 1997 and the NSF RI Award in 1990. I was Technical Program Chair for both the IEEE MASCOTS in 1994 and the IEEE Workshop on Parallel and Distributed Simulation in 1990. In 1989 I was recognized with the Ira Kay IEEE/ACM Best Paper Award for Best Paper presented at the IEEE Annual Simulation Symposium.

14. I have submitted approximately thirty invention disclosures and provisional patents over the past ten years. To date, I have been granted approximately ten patents.

15. I have testified as an expert witness before. Over the past six years, I've testified as an expert in more than 20 proceedings. About half of the proceedings in which I have testified as an expert were in the area of digital communication protocols and transceiver design, including six to seven in the area of digital physical layer design for transceivers.

16. Attached as Exhibit A is a copy of my CV.

II. INFORMATION AND MATERIALS CONSIDERED

17. In preparing this expert declaration I have considered the patents, their respective file histories, both parties' proposed constructions for certain terms (outlined below) appearing in those patents, as well as any additional documents I cite in this declaration, such as dictionaries.

18. I have considered the claim construction briefing, analysis, transcripts and opinions from the TQ Delta matters in Delaware.

19. I have relied also on my own personal knowledge relating to the technology at issue, including my education, work experience, and training in this field of art. I have also relied on my understanding of the training, knowledge, and skill level of a person of ordinary skill in the art at the time of the invention of the Family 1, 4 and 6 Patents.

III. PERSON OF ORDINARY SKILL IN THE ART

20. I understand that a person of ordinary skill in the art is considered to have the normal skills and knowledge of a person in a certain technical field, as of the time of the invention at issue. I understand that factors that may be considered in determining the level of ordinary skill in the art include: (1) the education level of the inventor; (2) the types of problems encountered in the art; (3) the prior art solutions to those problems; (4) the rapidity with which innovations are made; (5) the sophistication of the technology; and (6) the education level of active workers in the field.

21. With respect to the Asserted Patents, a person of skill in the art would have an electrical engineering background and experience in the design of multicarrier communication systems, such as those employing orthogonal frequency division multiplexing ("OFDM") or discrete multitone ("DMT") modulation. More particularly, a person of skill in the art would be a person with a bachelor's degree in electrical engineering (or a similar technical degree or equivalent work experience) and at least 3 years of experience working with such multicarrier communication systems.

22. I have over 30 years of combined industrial and academic experience in the architecture, design, development, testing and production of communication systems.

Furthermore, I have worked directly in the field of multicarrier communication systems, including product design and development, with many engineers meeting the standard defined in the previous paragraph for a person of skill in the art. Therefore, I certainly understand how a person of ordinary skill in the art would interpret or understand the claims of the Asserted Patents considering the specifications and file histories of the Asserted Patents.

IV. BACKGROUND OF THE TECHNOLOGY

A. Multicarrier Technology Concepts

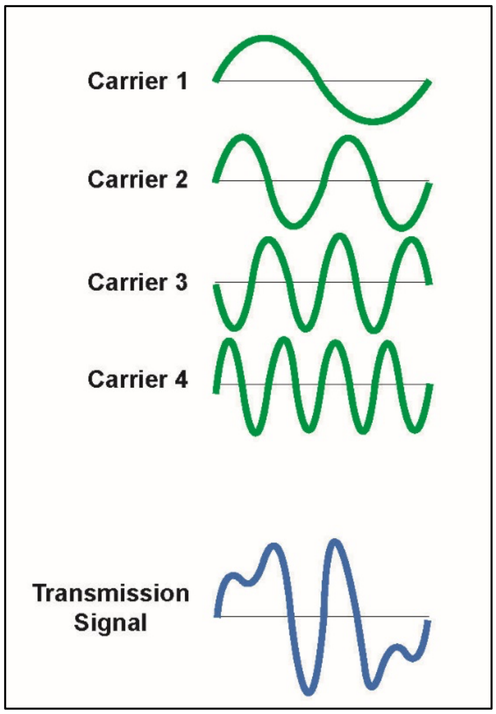
23. The TQD Patents Families describe inventive techniques for improving communication systems that transmit/receive multicarrier signals. A multicarrier signal includes several carrier signals (or carriers or subchannels), each operating at a different center frequency within the overall frequency band of the multicarrier communication channel, and each of which has been modulated to encode the value of one or more digital bits (e.g., "1" or "0"). Each carrier effectively serves as a separate, parallel sub-channel for carrying data.

24. Modulation is the process of encoding the value of one or more data bits onto a carrier signal by changing some characteristic of the carrier signal in accordance with the value of the one or more data bits. A multicarrier signal includes a number of carrier signals (or carriers[1]), each operating at a different center frequency within the overall frequency band of the multicarrier communication channel, and each having been modulated to encode the value of one or more digital bits (*e.g.*, "1" or "0"). Each carrier effectively serves as a separate, parallel sub-channel for carrying data. Each carrier is typically modulated to encode the value of a different bit or the values of different groups of bits; *i.e.*, the bit(s) encoded on a first carrier is/are typically different from the bit(s) encoded on a second carrier. The figure below illustrates four carrier signals (in

[1] In the art, the terms carrier, subcarrier, subchannel, and tone are used interchangeably.

practice there are typically hundreds or thousands of carriers). The carrier signals are combined as a group to produce a transmission signal, which is transmitted across a transmission medium (*e.g.*, phone lines, coaxial cable, etc.) to a receiving transceiver.

25. In the example below, carrier 1, carrier 2, carrier 3 and carrier 4 have different frequencies and are combined into one transmission signal.



26. Each carrier has a phase characteristic and an amplitude characteristic. A multicarrier transceiver may use the phase (or phase and amplitude) of the carriers to encode different values of different bits. For example, a phase of zero may represent a binary value of "1" and a phase of π (or 180°) may represent a binary value of "0". In the illustration above, Carriers 1, 2, and 4 have a phase of zero, and therefore each represent a "1". Carrier 3 has as phase of π (or 180 degrees), and therefore represents a "0". Note, Carrier 3 appears to be inverted from the other carriers (*i.e.*, compared to the others, its initial slope is negative), and that is how one can tell that Carrier 3 has a phase of π. Together, these four carriers encode input bits having binary values

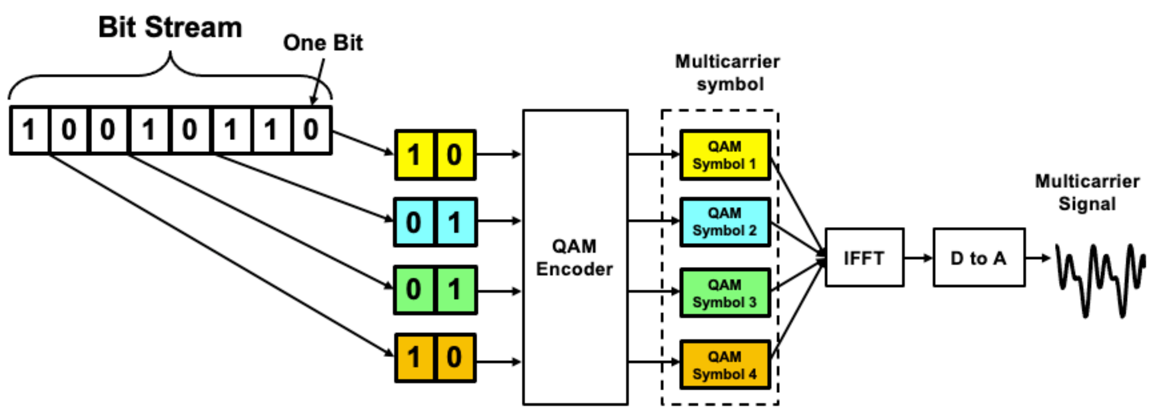
of 1, 1, 0, and 1. The phase and/or amplitude characteristic of the carriers are modulated by the same bits for a fixed period of time. This time period is referred to as the symbol period. In the next symbol period, a new set of bits from the input data may be used to modulate the carriers during the symbol period. In practice, a multicarrier transceiver can produce a multicarrier transmission signal that is a combination of many more than four carriers (*e.g*., hundreds or even thousands of carriers).

27. Relatedly, more than one bit per carrier may be encoded on the carriers by varying the phase and amplitude of carriers with greater granularity. For example, a transceiver may encode each carrier using a phase characteristic that takes one of many possible values in the range from 0 to 360 degrees (*i.e.*, 0 to 2π radians). Similarly, the transceiver may vary the amplitude characteristic for each carrier over a range determined by the transmit power level of the carrier. The number of unique combinations of phase and amplitude characteristics determines the number of bits sent at one time on a carrier. For example, if there are only two unique phases used on a carrier, only a single bit can be communicated at a time by that carrier, *i.e*., a "0" value of the bit is represented by one phase, $^{\pi}/_{2}$ for example, while a "1" value of the bit is represented by the other phase 3π /2; if there are four unique phase/amplitude combinations used on a carrier, two bits can be communicated at a time by that carrier, *i.e.*, two bits with values of 00, 01, 11, or 10; eight unique phase/amplitude combinations allow communicating three bits at a time per carrier, *i.e*., three bits with values of 000, 001, 011, 010, 100, 101, 111, or 110; *etc*. The number of bits that are encoded on a carrier at a time (*i.e.*, in one symbol period) is referred to as the "bit loading" for that carrier. The technique for encoding multiple bits onto one carrier by varying the phase (or phase and amplitude) is called quadrature amplitude modulation ("QAM"). By using multiple carrier signals and encoding the multiple carrier signals with several bits of input data, multicarrier

transceivers provide a high data carrying capacity.

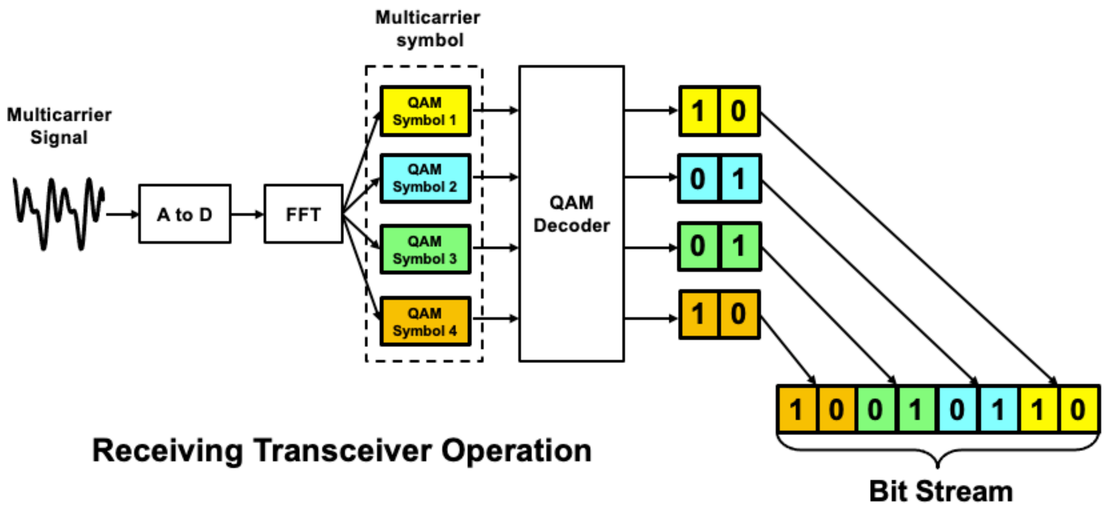
B. Multicarrier Transceiver Operation

28. Illustrative transmitting and receiving transceivers are depicted below.[2] The transmitting transceiver takes an input digital bit stream and generates a corresponding multicarrier signal that is transmitted across a given medium (e.g., the copper wires of a telephone line). The receiving transceiver receives the multicarrier signal and recreates the corresponding digital bit stream. The illustrations below depict the transceivers utilizing four carriers and two bits per carrier, but, in practice, there would be hundreds or thousands of carriers and there may be up to 15 bits per carrier.



Transmitting Transceiver Operation

[2] Paragraphs 25-27, above, includes a conceptual depiction of the component carrier signals of a multicarrier signal. The depiction is "conceptual" because, in the systems described in the TQ Delta Patent Families, the carrier signals do not actually exist as time-domain waveforms before the transmission signal is formed. Instead, a person of skill in the art would have understood that the carriers are represented by frequency-domain values and mathematically combined using the inverse fast Fourier transform (IFFT) operation, for example.



29. At the transmitting transceiver, a group of bits from the bit stream are assigned to a respective carrier of the multicarrier communication channel. As previously explained the number of bits assigned to each carrier is referred to as the bit loading. In the illustration above, a set of two bits are assigned to each carrier. For each carrier, the QAM encoder encodes the set of two bits as a "QAM symbol." A QAM symbol includes the frequency-domain values that represents the phase (or phase and amplitude) of the carrier. The set of QAM symbols that are modulated together at the same time is referred to as a "multicarrier symbol." If DMT (Discrete Multi-Tone) is being implemented, the set of QAM symbols is referred to as a "DMT symbol." The multicarrier signal that results from one DMT symbol has a duration of one DMT symbol period. A DSL system may transmit 4000 DMT symbols per second, which means that the DMT symbol period is 250 microseconds.

30. An inverse fast Fourier transform block ("IFFT") of the transmitting transceiver generates, from the QAM symbols of the DMT symbol, a block of time-varying discrete values or samples for a DMT symbol period. Each sample is the sum of the signal levels of all of the individual QAM-modulated carriers at that sample time instant, as well as a digital representation of the signal level of the transmission signal at a particular instant in time.

31. The digital-to-analog convertor (D-to-A) then serially converts each digital sample into its analog equivalent to create a time-domain analog DMT signal that is transmitted over the transmission medium (*e.g.*, wire). Each subsequent conversion of a digital sample is appropriately spaced in time such that the sequence of transmitted analog samples results in a continuous DMT signal that spans the DMT symbol period.

32. The receiving transceiver reverses the process: it receives the time-varying analog waveform and converts it into the original digital bit stream. The multicarrier analog signal is sampled and digitized by an analog-to-digital converter ("A to D"). The digital samples are processed by a fast Fourier transform ("FFT"), which simultaneously generates a plurality of QAM symbols—one for each carrier. The QAM symbols are then decoded by a QAM decoder into values of the bits. These values are then used to reconstruct the original digital bit stream that was input into the transmitting transceiver.

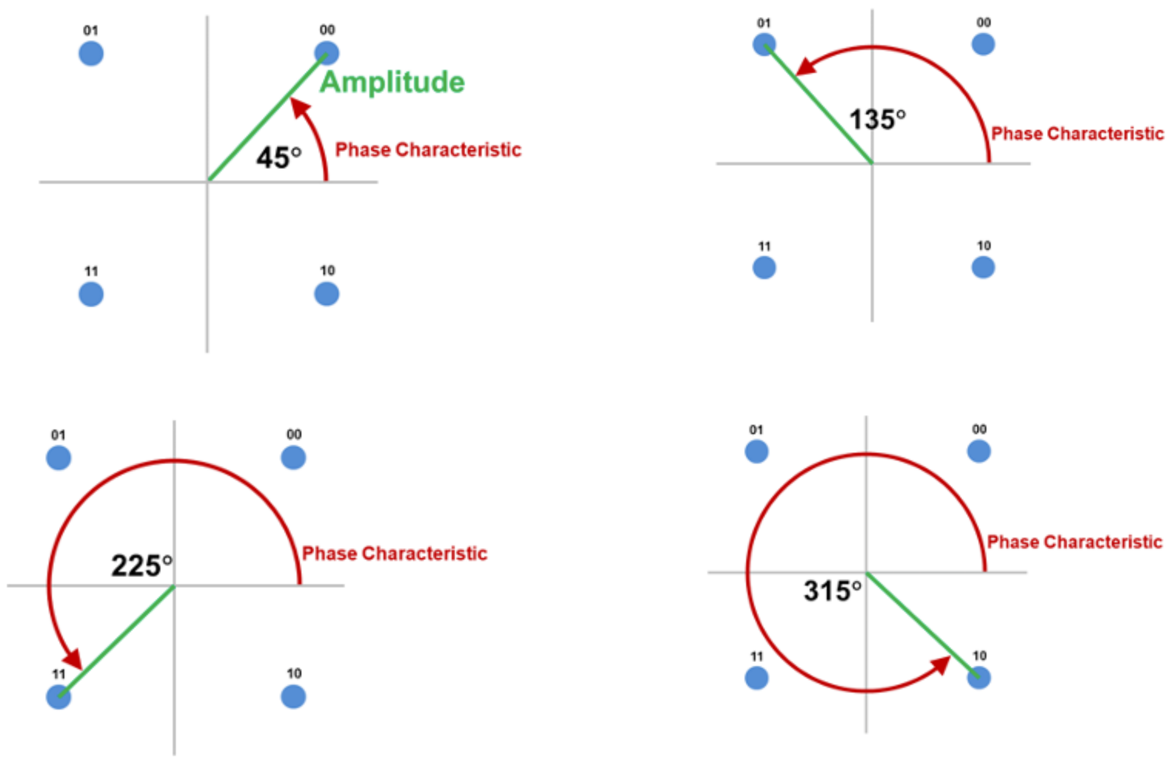
C. QAM Symbols

33. As described above, modulation that uses the phase and amplitude characteristics of a carrier to modulate bits is referred to as quadrature amplitude modulation ("QAM"). The values defining the phase and amplitude characteristics for a single QAM modulated carrier are called a QAM symbol.

34. Each QAM symbol can be conceptually illustrated by a QAM "constellation." In an illustrative example, a constellation with four different "constellation points" (referred to as "4-QAM") is depicted below. Each constellation point is depicted at a different location on a graph, and each point corresponds to one of the four possible different values for the four input bits—00, 01, 10 and 11. In DSL standard 4-QAM, each one the four possible 2-bit values corresponds to, and represents, a respective one of the four possible constellation points.

35. The location of a given constellation point on the graph can be specified by the "in-

phase" component "I" (a location along horizontal axis) and the "quadrature" component "Q" (a location along vertical axis) coordinates. This location can also be specified in "polar" coordinates—amplitude and phase. The following figures illustrated examples of the phase and amplitude characteristics for the four possible constellation points in 4-QAM (00, 01, 11 and 10). I note that in the particular 4-QAM scheme used by VDSL2, the position of the 01 constellation point and the 10 constellation point are swapped. *See* ¶ 95 (citing G.993.2 at 10.3.3.2 and Figure 10-9), *infra*.



36. The amplitude characteristic of a constellation point is the distance of the point to the origin of the graph. The phase characteristic is the angle of rotation about the origin from the positive I axis at which that point is located. Each constellation point has a unique combination of phase and amplitude characteristics. As illustrated above, in the 4-QAM modulation scheme, all the constellation points have the same amplitude, but have different phases. When using 4-

QAM, to encode a value of 00 on a carrier signal, the carrier signal is assigned a phase characteristic of 45 degrees, to encode a value of 01 on a carrier signal, the carrier signal is assigned a phase characteristic of 135 degrees, to encode a value of 11 on a carrier signal, the carrier signal is assigned a phase characteristic of 225 degrees and to encode a value of 10 on a carrier signal, the carrier signal is assigned a phase characteristic of 315 degrees. Given that a 4-QAM constellation point can have one of four phases and the same amplitude, a pair of bits can be used to represent the 4-QAM constellation point, i.e., a two-bit pair assigned to a carrier signal identifies the phase characteristic of the carrier signal.

V. The Family 1 ’686 Patent Background

37. The ’686 patent claims improvements to prior art devices, specifically multicarrier transceiver devices used for data communication. The multicarrier transceivers disclosed in the ’686 patent can communicate certain specified test and/or diagnostic information about the communication channel over which the multicarrier transceiver communicates. Fig. 1 is set forth below, reproduced from the ’686 patent, and illustrates a functional block diagram of an exemplary communications system according to this invention.

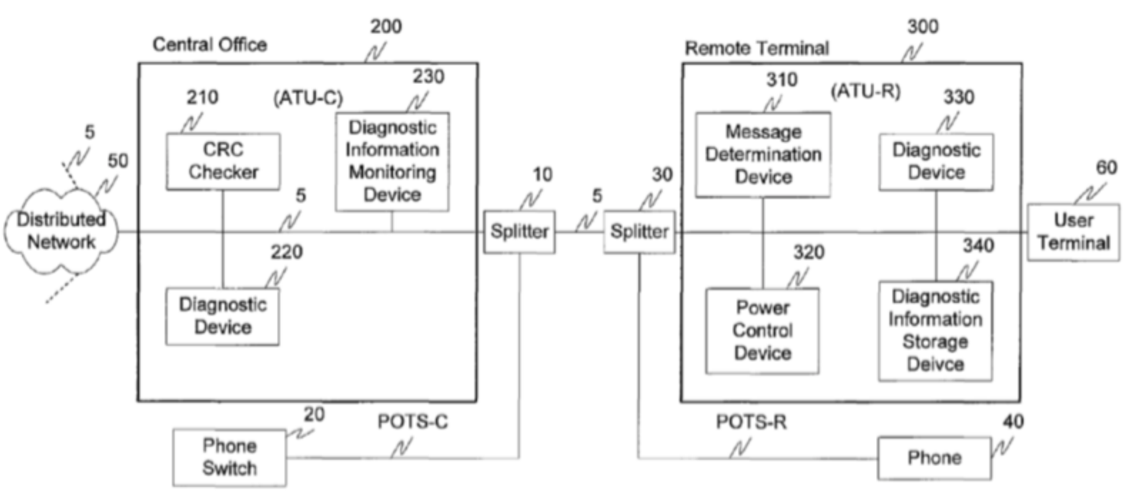


Fig. 1

’686 patent at Fig. 1.

38. Although the inventions of the diagnostic mode patents are described in the context of an Asymmetric Digital Subscriber Line (“ADSL”) system, the inventions are generally applicable to other multicarrier communication systems.

39. Referring again to Fig. 1 above, the ’686 patent discloses an exemplary list of test and diagnostic information that may be communicated between a first transceiver, Central Office 200, and second transceiver, Remote Terminal 300, for example. The test and diagnostic information are communicated over link 5.

40. The specific test and/or diagnostic information recited in the asserted claims of the ’686 patent includes “an array representing frequency domain received idle channel noise information.”

41. In some claimed embodiments, the multicarrier transceiver communicates the test and/or diagnostic information using a robust communication scheme where “each bit in the diagnostic message is mapped to at least one DMT symbol.” This slows down the bit rate so that only a single bit is communicated at a time by a DMT symbol, but it allows multicarrier communications over a communication channel even when the channel is impaired by noise or disturbances that would not otherwise support normal data communication. ‘686 Patent, Col 1:44-2:50, 3:44-67.

42. The above-described features of certain embodiments of the ’686 patent, facilitate diagnosis of potential service problems through detailed characterization of the multicarrier communication channel. This may be used to avoid a costly site visit by a technician. ’686 patent, 2:22–34.

A. The Family 1 Patents Are Not Indefinite

43. It is my understanding that Defendants allege that the following terms are

indefinite:

Term	Plaintiff's Proposed Construction	Defendants' Proposed Construction
"each bit in the diagnostic message is mapped to at least one DMT symbol" '686 Patent: Claim 17	Plain and ordinary meaning, which is: "each bit in the diagnostic message is communicated using a modulation scheme where a DMT symbol (or two or more DMT symbols) represents only a single bit of the diagnostic message"	Indefinite.
"DMT symbols that are mapped to one bit of the diagnostic message" '686 Patent: Claim 36	Plain and ordinary meaning, which is: "at least one bit in the diagnostic message is communicated using a modulation scheme where two or more DMT symbols represent only the same single bit of the diagnostic message"	Indefinite.
"at least one bit in the diagnostic message is mapped to at least one DMT symbol" '686 Patent: Claim 40	Plain and ordinary meaning, which is: "at least one bit in the diagnostic message is communicated using a modulation scheme where a DMT symbol (or two or more DMT symbols) represents only a single bit of the diagnostic message"	Indefinite.

44. I have been instructed that a claim term is indefinite if it fails to "inform, with reasonable certainty, those skilled in the art about the scope of the invention." *BASF Corp. v. Johnson Matthey Inc.*, 875 F.3d 1360, 1365 (Fed. Cir. 2017) (quoting *Nautilus, Inc. v. Biosig Inst.,*

Inc., 572 U.S. 898, 901 (2014)). As a person skilled in the art, I do not believe these terms are indefinite in the context of the '686 patent.

1. "each bit in the diagnostic message is mapped to at least one DMT symbol" ('686 patent, claim 17); "DMT symbols that are mapped to one bit of the di-agnostic message" ('686 patent, claim 36); "at least one bit in the diagnostic message is mapped to at least one DMT symbol" ('686 patent, claim 40)

45. The independent claims of the '686 patent recite a method of transmitting information using multicarrier modulation wherein "each bit in the diagnostic message is mapped to at least one DMT signal" (claim 17), "DMT symbols that are mapped to one bit of the di-agnostic message" (claim 36); "at least one bit in the diagnostic message is mapped to at least one DMT symbol" (claim 40)." This alternate modulation encoding scheme for transmitting diagnostic information is significantly different than transmitting information during normal data communication. Importantly, this robust communication scheme is intended to ensure that diagnostic information is reliably received even when normal data communication is otherwise impaired because of poor channel conditions. The specification of the '686 patent describes an embodiment of this claim element where "[i]n the one bit per DMT symbol modulation message encoding scheme, a bit with value 0 is mapped to the REVERB1 signal and a bit with a value of 1 [is] mapped to a SEGUE1 signal…. The REVERB1 signal is generated by modulating all of the carriers in the multi carrier system with a known pseudo-random sequence thus generating a wideband modulated signal. The SEGUE1 signal is generated from a carrier by 180-degree phase reversal of the REVERB1 signal." '686 patent at 3:61–63.

46. A person of ordinary skill in the art would understand this to mean that to transmit a bit value of "1", a known pseudo-random sequence is used to modulate all of the carriers being used during one DMT symbol (to generate a wideband modulated signal) and to transmit a constellation point of value "0", and a different known pseudo-random sequence — typically the

inverse of the first sequence — is used to modulate one DMT symbol for the carriers being used. This scheme uses one DMT symbol to communicate one bit of information, i.e., only a single bit of the diagnostic information is transmitted by the DMT signal in a single DMT symbol period. This results in slower, but far more robust communication in a diagnostic mode and allows communication over the same multicarrier communication channel that is being diagnosed to determine the cause of impairment.

47. I have considered the claim construction briefing and the Delaware Court's claim construction analysis and orders and agree with that the Delaware Court's construction represents the understanding of a person of ordinary skill in the art.

48. A person of ordinary skill in the art understands that "each bit in the diagnostic message is mapped to at least one DMT symbol" as recited in claim 17 means "each bit in the diagnostic message is communicated using a modulation scheme where a DMT symbol (or two or more DMT symbols) represents only a single bit of the diagnostic message:" that "DMT symbols that are mapped to one bit of the di-agnostic message" as recited in claim 36 means "at least one bit in the diagnostic message is communicated using a modulation scheme where two or more DMT symbols represent only the same single bit of the diagnostic message;" and that "at least one bit in the diag-nostic message is mapped to at least one DMT symbol" as recited in claim 40 means "at least one bit in the diagnostic message is communicated using a modulation scheme where a DMT symbol (or two or more DMT symbols) represents only a single bit of the diagnostic message." These claim phrases are therefore not indefinite to a person of ordinary skill in the art.

VI. FAMILY 4 PATENTS: REDUCING Peak-to-Average power Ratio (PAR)

49. The Family 4 Patents relate to communication systems that use multicarrier modulation. The inventions described in the Family 4 Patents relate, in part, to reducing the Peak-

to-Average power Ratio (PAR) of a transmitted multicarrier signal. *See* '008 patent at 1:26-29

A. Multicarrier Technology Concepts

50. The Family 4 Patents explain that:

> In a conventional multicarrier communications system, signal transmitters communicate over a communication channel using multicarrier modulation or Discrete Multitone Modulation (DMT). Carrier signals (carriers) or sub-channels spaced within a usable frequency band of the communication channel are modulated at a symbol (i.e., block) transmission rate of the system.

'627 Patent at 1:25-32.

51. To effectuate the communication of data bits:

> [a]n input signal, which includes input data bits, is sent to a DMT transmitter, such as a DMT modem. The DMT transmitter typically modulates the phase characteristic, or phase, and amplitude of the carrier signals using an Inverse Fast Fourier Transform (IFFT) to generate a time domain signal, or transmission signal, that represents the input signal. The DMT transmitter transmits the transmission signal, which is a linear combination of the multiple carriers, to a DMT receiver over the communication channel.

'008 Patent at 1:39-47.

B. The Inventions of the Family 4 Patents

52. The Family 4 Patents claim improvements to multicarrier transceiver devices used for data communication. The Family 4 Patents recognize that the "peak-to-average-power ratio" ("PAR") of a multicarrier transmission signal is an important consideration when designing multicarrier transceivers.

> The PAR of a transmission signal is the ratio of the instantaneous peak value (i.e., maximum magnitude) of a signal parameter (e.g., voltage, current, phase, frequency, power) to the time-averaged value of the signal parameter.

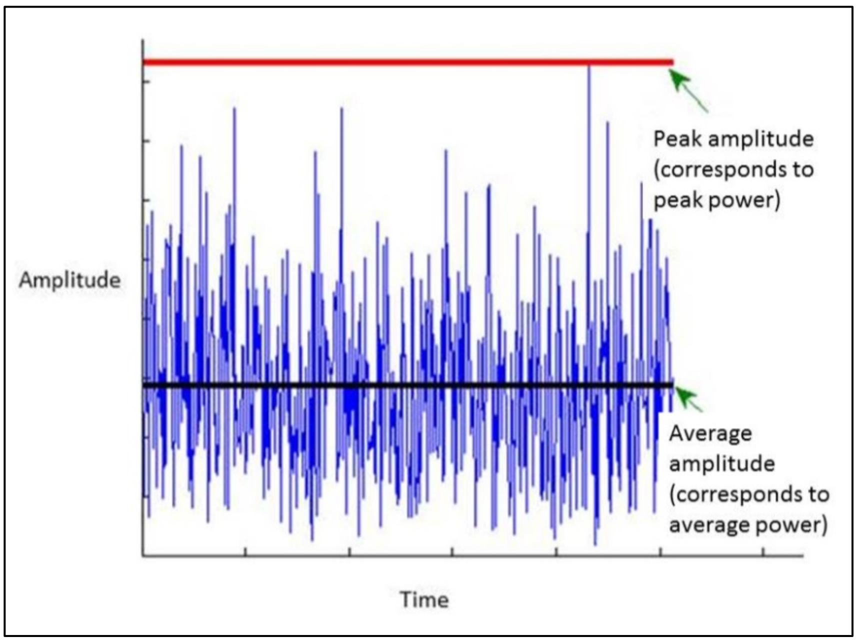
'627 Patent at 1:60-64.

> The PAR of a transmission signal transmitted and received in a DMT communication system is an important consideration in the design of the DMT communication system because the PAR of a signal affects the communication

> system's total power consumption and component linearity requirements of the system.

'008 Patent at 1:65-2:2.

53. The graph below illustrates the concepts of peak power and average power of such a transmission signal. The peak amplitude of a signal corresponds to the peak power, and the average amplitude of the signal corresponds to the average power. In the graph below, the peak amplitude is about three times higher than the average amplitude, resulting in a peak power that is about nine times the average power, or 9.5 dB PAR.



54. The inventors of the Family 4 Patents recognized that when the phases of the carriers are not sufficiently random, the PAR of the transmission signal can increase to a level at which "clipping" occurs at an unacceptably high rate. '627 Patent at 2:15-16; 2:20-23 ("If the phase of the modulated carriers is not random, then the PAR can increase greatly. … An increased PAR can result in a system with high power consumption and/or with high probability of clipping the transmission signal."). Conversely, when phases are sufficiently random, the DMT signal can be approximated as having a Gaussian probability density and therefore has a low PAR.

> The phase and amplitude of the carrier signals of DMT transmission signal can be considered random because the phase and amplitude result from the modulation of an arbitrary sequence of input data bits comprising the transmitted information. Therefore, under the condition that the modulated data bit stream is random, the DMT transmission signal can be approximated as having a Gaussian probability distribution.

'008 Patent at 1:52:55; *see also id.* at 1:60-65.

55. If the PAR of a transmission signal is high, a system that is designed to transmit that instantaneous peak power without distortion may consume a high amount of power from its power supply all the time, including when the signal has a much lower instantaneous power. Alternatively, a high-PAR signal may exceed the acceptable operating ranges of transmitter and/or receiver components, thereby degrading the signal (*e.g.*, causing the signal to be "clipped" or distorted). *See* '008 at 2:6–30.

56. The inventors of the Family 4 Patents recognized several situations where the phases of the modulated carrier signals used to generate the multicarrier transmission signal may not be sufficiently random thereby resulting in a signal with an unacceptably high PAR.

> Examples of cases where the phases of the modulated carrier signals are not random are when bit scramblers are not used, multiple carrier signals are used to modulate the same input data bits, and the constellation maps, which are mappings of input data bits to the phase of a carrier signal, used for modulation are not random enough (i.e., a zero value for a data bit corresponds to a 90 degree phase characteristic of the DMT carrier signal and a one value for a data bit corresponds to a -90 degree phase characteristic of the DMT carrier signal). An increased PAR can result in a system with high power consumption and/or with high probability of clipping the transmission signal.

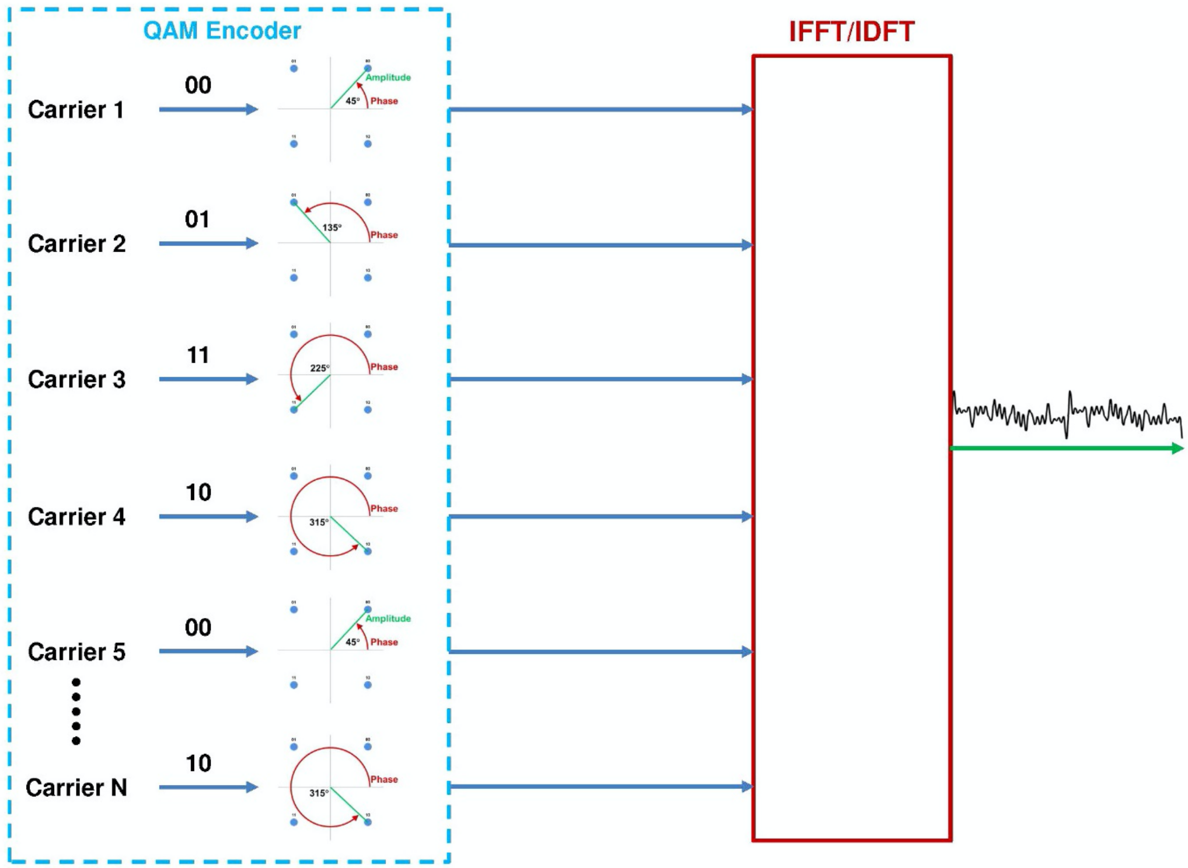
'008 Patent at 2:16-27.

57. The inventions described in the Family 4 Patents may be used to reduce the PAR of a transmission signal when multiple carrier signals are used to modulate the same input data bits. The result of using multiple carrier signals to modulate the same input data bits is that the input data bits are communicated repeatedly on the multiple carrier signals. The advantage of

repeating the same data bits on multiple carrier signals, *i.e.*, using multiple carriers to modulate the same input data bits, is that it allows the receiving transceiver to decode the repeated bits with a lower probability of error than that of bits that are transmitted on only a single carrier. Communicating the value(s) of the same bit(s) on multiple carrier signals allows critical data like initialization information to be reliably received, especially when the transmission characteristics of the communication medium are not completely determined, as will be the case during the process of initialization of a DSL system. However, as the Family 4 Patents recognize, when multiple carrier signals are used to modulate the values of the same bits, the resulting transmission signal may have an unacceptably high PAR in which samples corresponding to the high peak values of a DMT symbol will clip. The Family 4 Patents explain how to reduce the "peak-to-average-power ratio" ("PAR") of a multicarrier transmission signal.

58. By way of example, claim 14 of the '008 Patent provides, in relevant part, a multicarrier transceiver where multiple carrier signals are used to modulate the value of the same bit. To ameliorate the increased PAR, the claim further provides computing a phase shift for each carrier signal based on a value determined independently of any bit value of the bit stream carried by that respective carrier signal where the value is determined using a pseudorandom number generator, and combining the phase shift computed for each carrier signal with the phase characteristic of that carrier signal so as to substantially scramble the phase characteristics of the plurality of carrier signals.

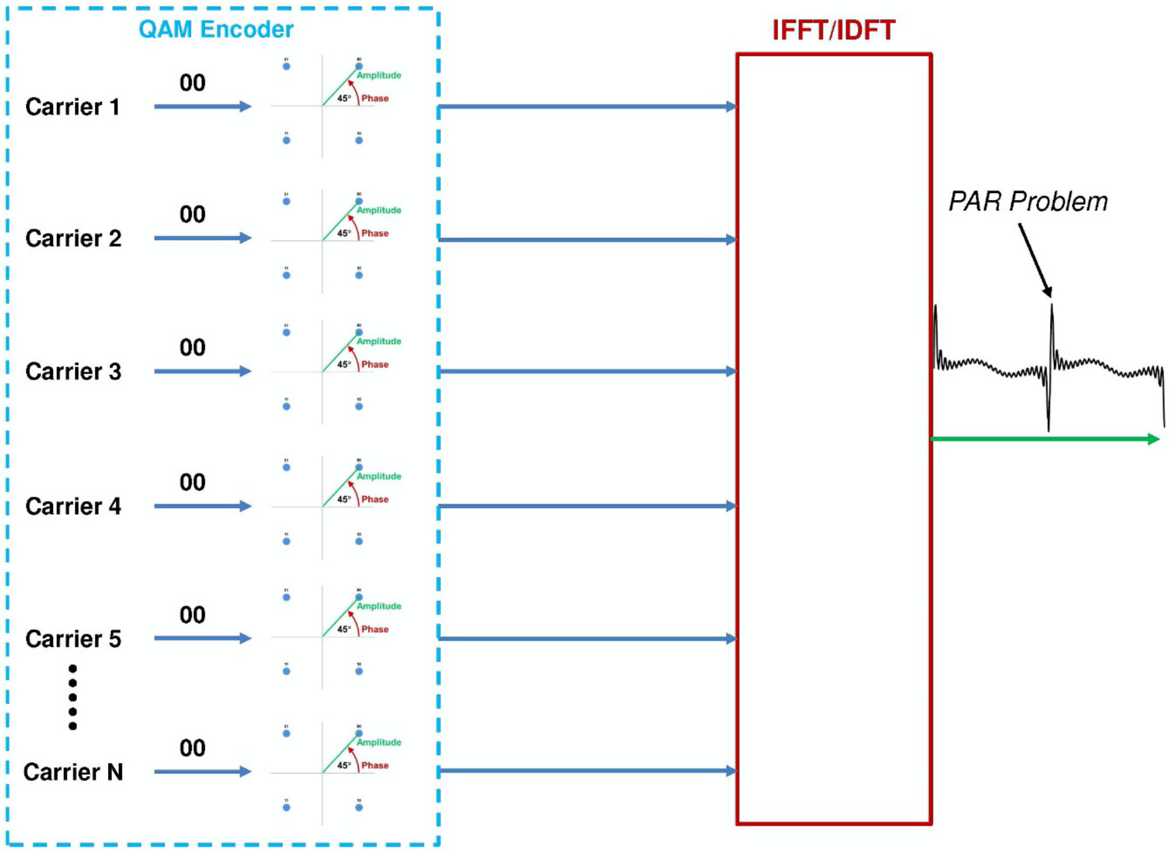
59. Consider the following illustration of a system in which the 2-bit values modulated on the N carriers are sufficiently random. Because the values are random, the transmitted multicarrier signal has a low PAR approximating that of a Gaussian distribution.



60. Note the variance in the phases (red arcs) depicted in the QAM constellations above. Because of the variability in input data (the four bits encoded on each carrier vary sufficiently), the phases of the QAM symbols are sufficiently random and, therefore, the output transmission signal does not include large peaks (or "spikes") causing a PAR significantly greater than that for a Gaussian distribution.

61. However, in a situation in which the values of the bits encoded on each of the carriers is the same, the phases of the QAM symbols will be the same. This leads to power spikes in the output transmission signal, which can present a PAR problem if those spikes exceed the capabilities of the transceiver (*e.g.*, there are large spikes causing a PAR significantly greater than that for a Gaussian distribution). As shown below, each of the N carrier signal was modulated

with the same 2-bit value – 00.



62. As explained earlier, the Family 4 Patents disclose inventive transceivers that communicate the values of the same bits on multiple carriers but do so in a manner that reduces the PAR of a transmission signal by scrambling the phases of the carriers. FIG. 1 (which is reproduced and annotated below) is illustrative:

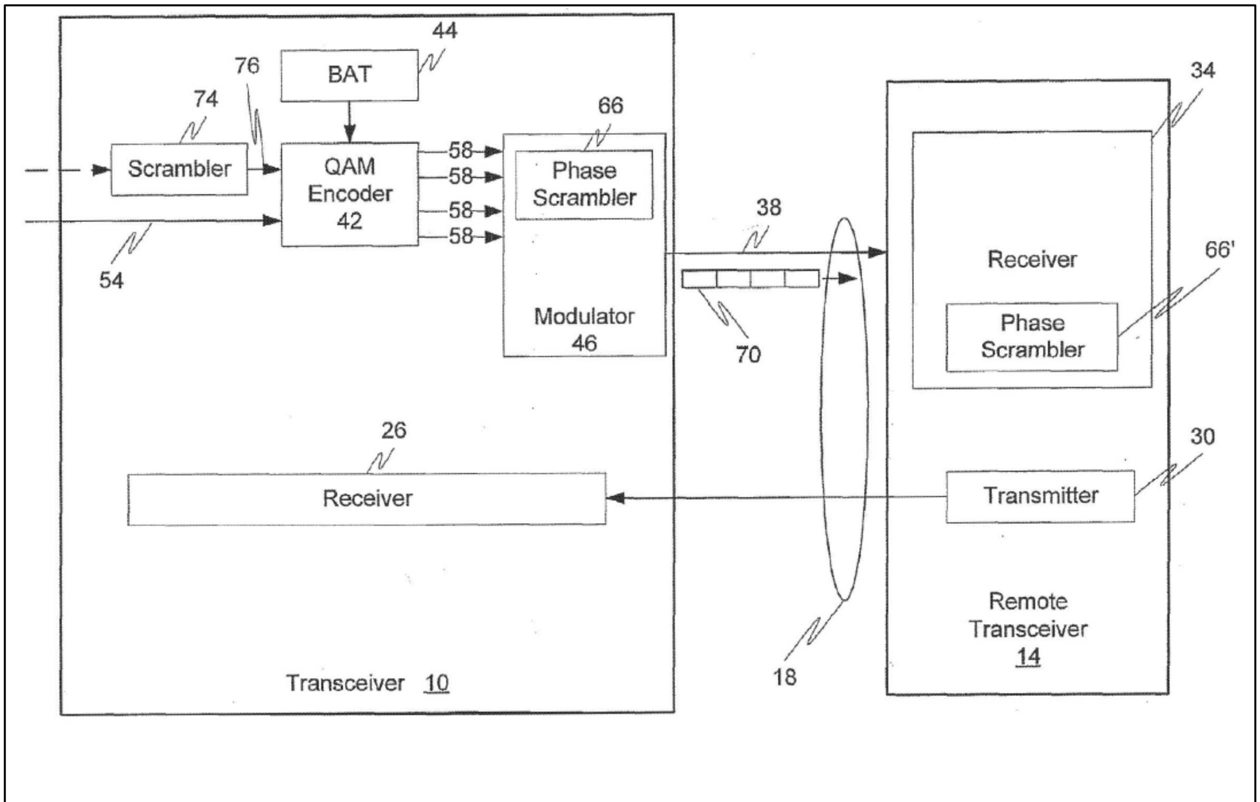


Fig. 1

63. As depicted, an input bit stream 76 (which has been scrambled by a different type of scrambler—a "bit scrambler" 74)[3] is received by the QAM encoder 42. '008 patent at 5:10–14. The QAM encoder 42 assigns a QAM symbol 58 for each carrier based on the input bit stream 76 and the BAT 44 that specifies the number of bits carried by each carrier signal, and then outputs those QAM symbols 58 in parallel to a modulator 46. '008 patent at 3:63–4:9. When all of the carriers carry the same number of bits, the functionality of the QAM encoder and the BAT can be accomplished by grouping the bits into the same size groups. The modulator 46 includes a phase scrambler 66 and an IFFT or IDFT. In some embodiments, the phase scrambler is external to the

[3] A bit scrambler is structurally and functionally different from a phase scrambler. A bit scrambler is used to avoid a long sequence of binary 1s or 0s. It operates by scrambling the bits in accordance with a polynomial. *See* Understanding Digital Subscriber Line Technology by Thomas Starr, John M. Cioffi and Peter J. Silverman (1999) at pp. 285-286. Further, the bits in the input bit stream to a bit scrambler are not associated with carrier signals.

modulator. The phase scrambler 66 scrambles the phases of the QAM symbols 58, and the IFFT/IDFT converts the scrambled QAM symbols into a digital signal which is then converted to an analog time-domain transmission signal 38 representing a sequence of DMT symbols 70. The transmission signal 38 is sent across a transmission medium to a remote transceiver 14. *Id.* at 4:10–38.

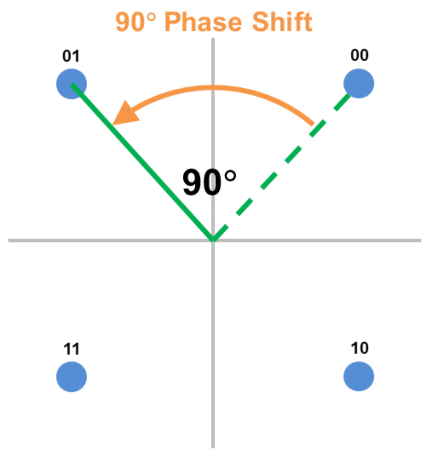
64. The phase scrambler 66 computes a phase shift for the carrier signals. The '627 Patent explains that:

> To compute a phase shift for each carrier signal, the phase scrambler 66 associates one or more values with that carrier signal. The phase scrambler 66 determines each value for a carrier signal independently of the QAM symbols 58, and, therefore, independently of the bit value(s) modulated onto the carrier signal. The actual value(s) that the phase scrambler associates with each carrier signal can be derived from one or more predefined parameters, such as a pseudorandom number generator (pseudo-RNG), a DMT carrier number, a DMT symbol count, a DMT superframe count, a DMT hyperframe count, and the like[.]

'008 patent at 4:48-63.

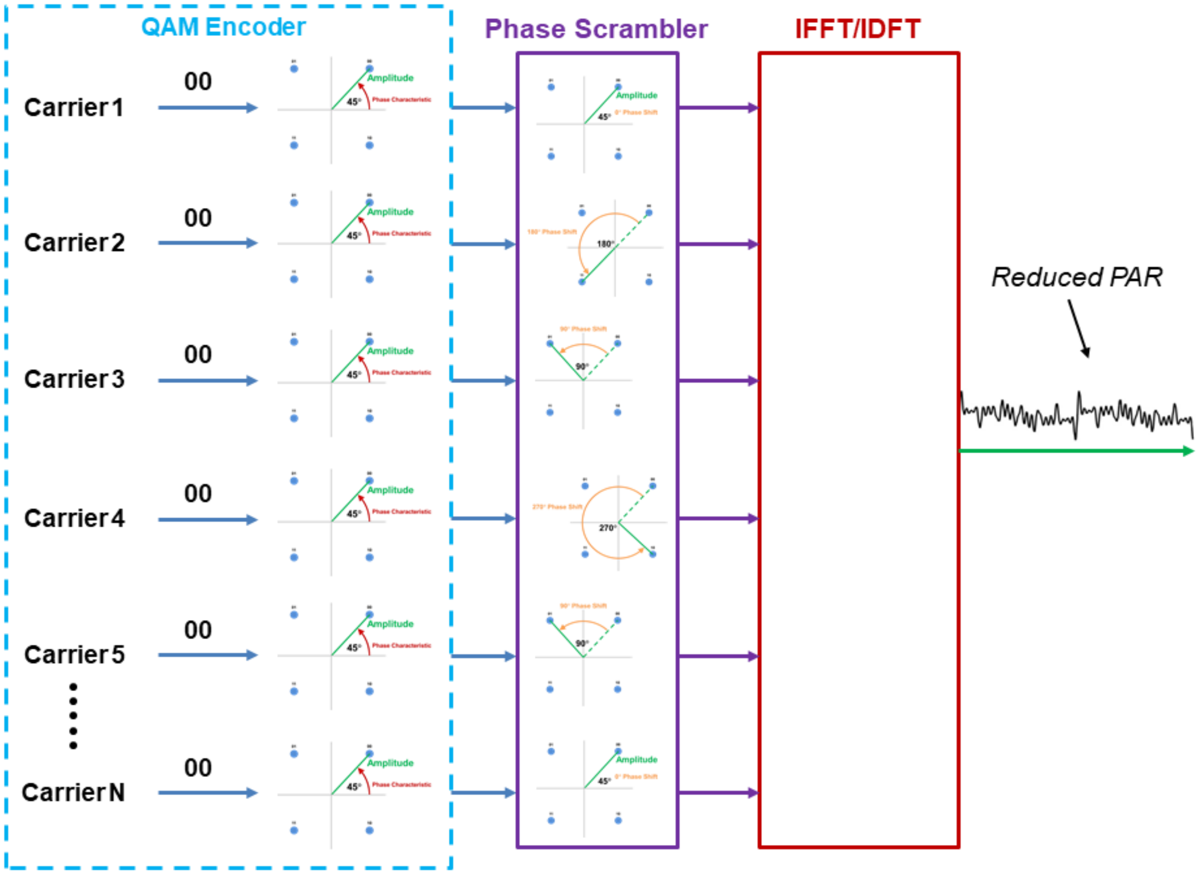
65. The transmission signal 38 is then processed by the remote transceiver 14 to regenerate the original input bit stream 76. '008 patent at 4:29-47. One having ordinary skill in the art would appreciate that the remote transceiver includes an FFT/DFT (pink) that is complementary to the transmitting transceiver's IFFT/IDFT. The FFT/DFT reverses the process of the IFFT/IDFT. Specifically, the FFT/DFT converts a digitized transmission signal 38 into a plurality of QAM symbols (one for each carrier). These QAM symbols are then processed by the phase descrambler 66' (orange), which recovers the original QAM symbols 58. These symbols 58 are decoded by a QAM decoder (not shown) to recreate the original bit stream 76.

66. Shown below is the 4-QAM constellation point that results when the 45-degree phase characteristic of a carrier signal is phase shifted by 90 degrees. The phase shift of 90 degrees is computed by the phase scrambler based on the value of a pseudo-random number.



67. Based on the value of the pseudo-random number, the phase scrambler may generate phase shifts of 0, 90, 180 or 270 degrees. Each generated phase shift is then associated with a carrier signal and the phase characteristic of that carrier signal is then rotated by the generated phase shift.

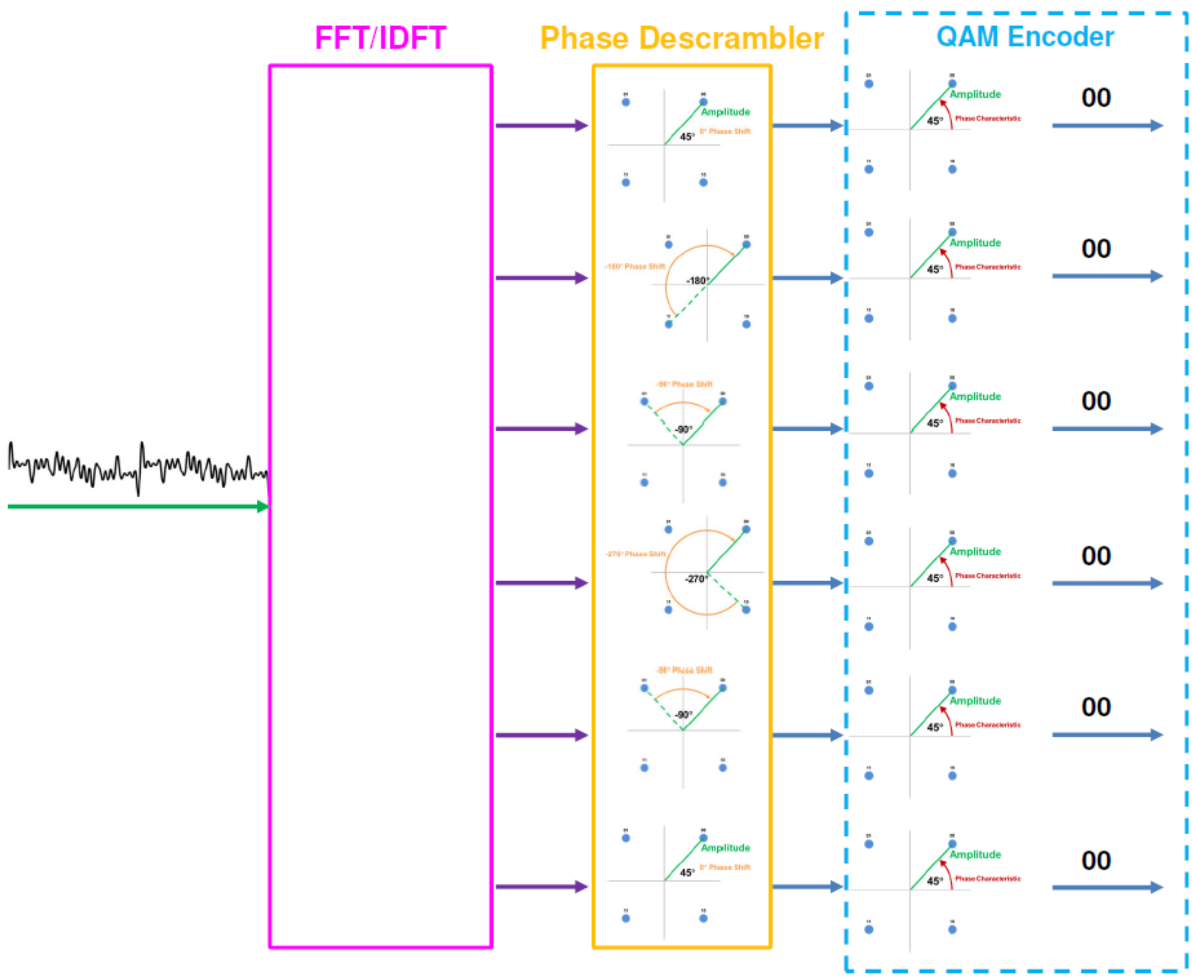
68. To further illustrate the principle of phase scrambling, the drawing below depicts a QAM encoder (blue) and a modulator in the transmitting transceiver that has both an IFFT/IDFT (red) and a phase scrambler (purple).



69. As explained above, the phase scrambler receives QAM symbols output from the QAM encoder. In this example, the phases of the QAM symbols (red arcs) output from the QAM encoder are identical. In the example above, the phase scrambler can generate one of four unique phase shifts based on the value of a pseudo-random number – 0, 90, 180 or 270 degrees. The phase scrambler then scrambles the phases of the carrier signals by adjusting the phase characteristic of the carrier signals by the randomly generated phase shifts. In the illustration above, the phase characteristics of carriers 1 and N are subjected to a phase shift of 0 degrees, the phase characteristic of carrier 2 is subjected to a phase shift of 180 degrees, the phase characteristics of carriers 3 and 5 are subjected to a phase shift of 90 degrees and the phase characteristic of carrier 2 is subjected to a phase shift of 270 degrees. These adjustments scramble

or randomize the carrier phases, which would otherwise have been the same. The amplitudes and scrambled phases for each carrier are then processed by the IFFT/IDFT to generate a transmission signal (green). In this way, even though the input bits for each carrier are identical, the resulting phases of the carriers in the transmission signal are sufficiently random.

70. At the receiver, the process is reversed. By using the same pseudo-random number series that was used by the transmitting transceiver for phase scrambling, a receiving transceiver can descramble the carrier phases to recover the transmitted data.



C. The '008 Patent is not Indefinite

71. I have been asked to evaluate whether the following claim phrase from claim 14 of

the ’008 Patent is indefinite: “multiple carrier signals corresponding to the scrambled carrier signals are used by the first multicarrier transceiver to modulate the same bit value.”

72. In the context of the Family 4 patents, this term can be understood by a person of ordinary skill in the art to mean “a first carrier signal is used by the first multicarrier transceiver to modulate the value of a bit and at least one more carrier signal is used by the first multicarrier transceiver to modulate the value of the same bit, wherein the carrier signals correspond to the scrambled carrier signals.”

73. This claim term specifies that modulation is performed, so the term refers to activity being performed in a transmitting transceiver (i.e., “the first [multicarrier] transceiver”). When a multicarrier signal is transmitted, by definition, multiple carrier signals are used by the transmitting transceiver to modulate data carried in a transmission signal. The transmitting transceiver transmits a bit stream (which is encoded in the carrier signals). The transmitted bit stream can include many different bits, each of which has an associated value—i.e., a “0” or a “1”.

74. According to claim 14, “multiple carrier signals ... are used by the first multicarrier transceiver to modulate the same bit value.” This claim language requires that the “same bit” (with the same value) is carried on multiple carrier signals. Such a scenario is illustrated in ¶¶ 42–51, above, as a form of coding or redundancy, and typically results in a reduced probability of error for the “same bit.” It is also described in the specification: “Examples of cases where the phases of the modulated carrier signals are not random are when bit scramblers are not used, multiple carrier signals are used to modulate the same input data bits, and the constellation maps, which are mappings of input data bits to the phase of a carrier signal, used for modulation are not random enough….” ’008 patent at 2:15–30 (emphasis added). Thus, a first carrier signal is used by the transmitting transceiver to modulate the value of a bit, and at least one more carrier signal is used

by the transmitting transceiver to modulate the value of the same bit.

75. Furthermore, according to the language of the claim, the "multiple carrier signals correspond[] to the scrambled carrier signals."

76. I have considered the briefing in the Delaware Court and the Delaware Court's construction and analysis and agree that the Delaware Court's construction represents an understanding of a person or ordinary skill in the art.

77. Consequently, a person of ordinary skill in the art would understand that one way to express the meaning of this claim phrase is as follows: "a first carrier signal is used by the first multicarrier transceiver to demodulate the value of a bit of the received bit stream and at least one more carrier signal is used by the first multi carrier transceiver to demodulate the value of the same bit of the received bit stream, wherein the carrier signals correspond to the plurality of phase-shifted and scrambled carrier signals." Because a person of ordinary skill in the art understands the meaning of the phrase, in my opinion it is not indefinite.

VII. FAMILY 6: INTERLEAVING AND FORWARD ERROR CORRECTION

78. DSL is a technology that allows high-speed data communication of digital data to be made over telephone lines. DSL is commonly used to provide broadband service for access to the Internet.

79. Standardized DSL protocols are defined by, for example, the ADSL series of ITU-T G.992.x standards, e.g., ITU-T Recommendation G.992.3 (07/2002) (hereinafter "G.992.3" or "ADSL2") and the VDSL series of ITU-T G.993.x standards, e.g., ITU-T Recommendation G.993.2 (12/2011) (hereinafter "G.993.2" or VDSL2).

80. DSL employs a multicarrier communication scheme. In a multicarrier communication scheme, a number of "subcarriers" (or "carriers"), each having a discrete, non-

overlapping frequency, are used to communicate data. The VDSL2 standard, for example, may use several thousand subcarriers to transmit and receive data. Each subcarrier, in turn, uses quadrature amplitude modulation (or "QAM") to transmit up to 15 bits at a time. The symbol rate of DSL is approximately 4000 times per second and, thus, DSL has the ability to transmit data at rates up to 100 million bits per second or more.

A. Interleaving and Error Correction

81. DSL operates in a harsh environment. Telephone lines were designed to carry analog voice signals, not high-speed digital data. The wires themselves are not electromagnetically shielded, and they run relatively long distances through an environment that subjects the wires to interference from electrical noise sources, including power lines, radio signals, and other telephone lines and data services. The '835 patent states:

> Communications systems often operate in environments that produce impulse noise. Impulse noise is a short-term burst of noise that is higher than the normal noise that typically exists in a communication channel. For example, DSL systems operate on telephone lines and experience impulse noise from many external sources including telephones, AM radio, HAM radio, other DSL services on the same line or in the same bundle, other equipment in the home, etc. It is standard practice for communications systems to use interleaving in combination with Forward Error Correction (FEC) to correct the errors caused by impulse noise.

'835 patent at 1:27-37.

82. As explained in the '835 patent, interleaving in combination with Forward Error Correction (FEC) are techniques used to reduce errors in the reception of data caused by impulse noise (*i.e.*, short-term bursts of high noise). Interleaving (or an interleaver) modifies an input byte stream (e.g., a group of eight bits) by delaying transmission of some of the bytes by different amounts. This spreads out bytes that were adjacent in the input byte stream according to a known pattern to produce an output byte stream. An interleaver is used in a transmitter, and a de-interleaver is used in a receiver to put the bytes back in the same order as they were in the original

input byte stream.

83. Interleaving is used to improve the performance of Forward Error Correction ("FEC"). FEC schemes, such as "Reed-Solomon encoding," encode input data bits into "codewords" that include the input data bits and additional "parity" bits. The FEC encoding results in a FEC output byte stream of, e.g., Reed-Solomon ("RS") codewords. Bytes of each RS codeword are spread out by the interleaver and interleaved with bytes from other RS codewords. By spreading out the bytes of each codeword, if there is an impulse noise event, a relatively smaller percentage of the bits of any given codeword will be corrupted. In this way, if enough of the bytes of a codeword are received, the RS decoding process can recover all of the data bits encoded into the RS codeword.

84. DSL systems typically uses a type of interleaver called a "convolutional interleaver." *See* G.992.3 at p. 40 (describing "spread[ing] the Reed-Solomon codeword and therefore reduc[ing] the probability of failure of the FEC in the presence of impulse noise, the FEC Output Data Frames shall be convolutionally interleaved"). A convolutional interleaver partitions its input into "blocks" of bytes, and its operation is defined by two parameters: the block length "I" and the depth parameter "D." Given these two parameters, a convolutional interleaver works as follows: (1) the first byte of each input block is not delayed in the output, (2) the second byte of each input block is delayed by D-1 bytes, such that it is spaced D bytes from the first byte in the output, (4) the third byte is delayed such that it is spaced D bytes from the second byte in the output, (5) and so on, spreading out the bytes of an input block such that any two bytes in the block that were once adjacent to each other are now D bytes away from each other. This results in the last byte of the block (the "I" byte) being delayed (I-1)*(D-1) from its original position. This operation is depicted in Figure 1 below, using example parameters I=5 and D=3:

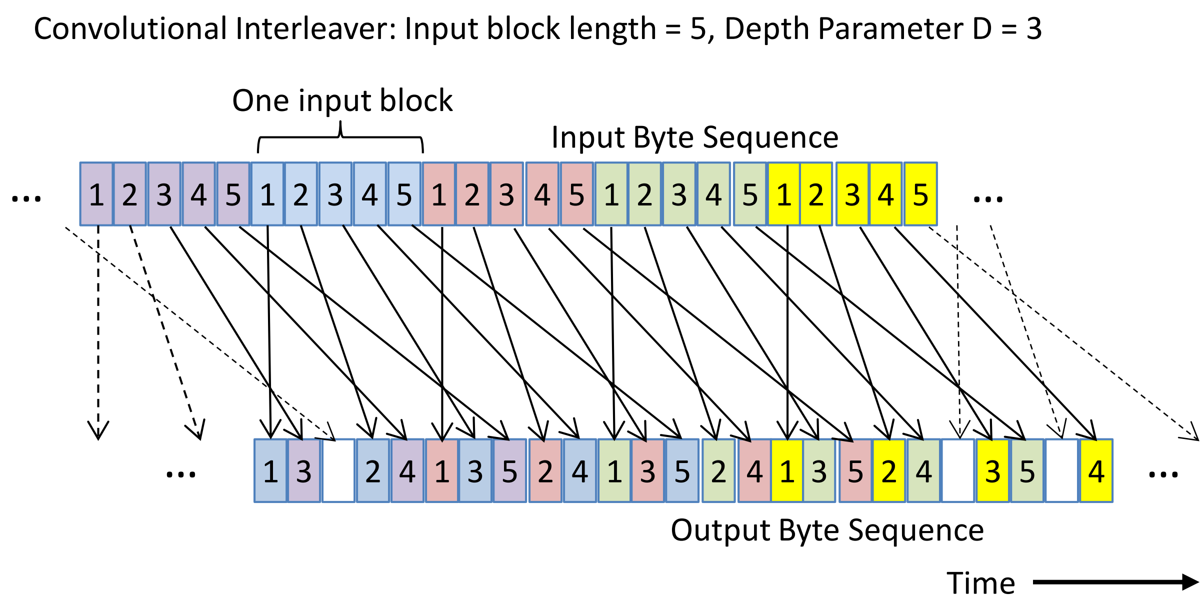


Figure 1: Convolutional interleaver with I = 5 and D = 3.

85. Figure 1 can be described as follows: (1) the position indexing 1, 2, 3, 4 and 5 of the bytes in each color-coded input block are for the convenience of the reader, and do not necessarily refer to specific data values; (2) the input byte stream and output byte streams are continuous, as represented by ellipses, (3) arrows coming from input bytes not shown or going to output bytes not shown are dashed instead of solid.

86. With reference to the input block shown in Figure 1 above that is colored blue and annotated "One input block," its first byte "1" is not delayed and, therefore, its arrow is straight down to the same blue "1" in the output sequence. However, its byte "2" is delayed by 2 spaces (or byte positions) from where it would otherwise have been placed in the output sequence (because (2-1)*(D–1) = (2-1)*(3–1) = 2), thus delaying it 2 byte positions from where it would have been and placing it three away from the blue "1" in the output. Likewise, the blue "3," "4" and "5" are delayed by 4, 6 and 8 respectively from where they would have been had the sequence not been interleaved, thereby spacing the blue input bytes by three from each other in the output (because the interleaver depth parameter D is three in this example).

87. § 7.7.1.5 of the ADSL2 (G.992.3) standard describes this operation states:

> Convolutional interleaving is defined by the rule (using the currently defined values of the framing control parameters D_p and the derived parameter $N_{FEC.p}$):
>
>> Each of the $N_{FEC.p}$ octets $B_0, B_1, \ldots, B_{NFEC.(p-1)}$ in an FEC Output Data Frame is delayed by an amount that varies linearly with the octet index. More precisely, octet B_i (with index i) is delayed by $(D_p - 1) \times i$ octets, where D_p is the interleaver depth.
>
> An example for $N_{FEC.p} = 5$, $D_p = 2$ is shown in Table 7-13, where B_i^j denotes the i-th octet of the j-th FEC Output Data Frame.

Table 7-13/G.992.3 – Convolutional interleaving example for $N_{FEC.p} = 5$, $D_p = 2$

Interleaver input	B_0^j	B_1^j	B_2^j	B_3^j	B_4^j	B_0^{j+1}	B_1^{j+1}	B_2^{j+1}	B_3^{j+1}	B_4^{j+1}
Interleaver output	B_0^j	B_3^{j-1}	B_1^j	B_4^{j-1}	B_2^j	B_0^{j+1}	B_3^j	B_1^{j+1}	B_4^j	B_2^{j+1}

88. The "octet index" described in § 7.7.1.5 of G.992.3 corresponds to the byte position. Table 7-13/G.992.3 shows the same relationship between interleaver input byte positions and interleaver output byte positions as discussed with respect to the colorized Figure 1 except that an interleaver depth of 2 (for Table 7-13/G.992.3) is used instead of 3 (for Figure 1).

89. Figure 2 below shows interleaver inputs and outputs where an interleaver block size of I=7 and an interleaver depth of D=5 is used. The upper portion of the figure shows how the blue block is spread out in the interleaver output. The lower portion of the figure shows how adjacent output bytes come from many other blocks.

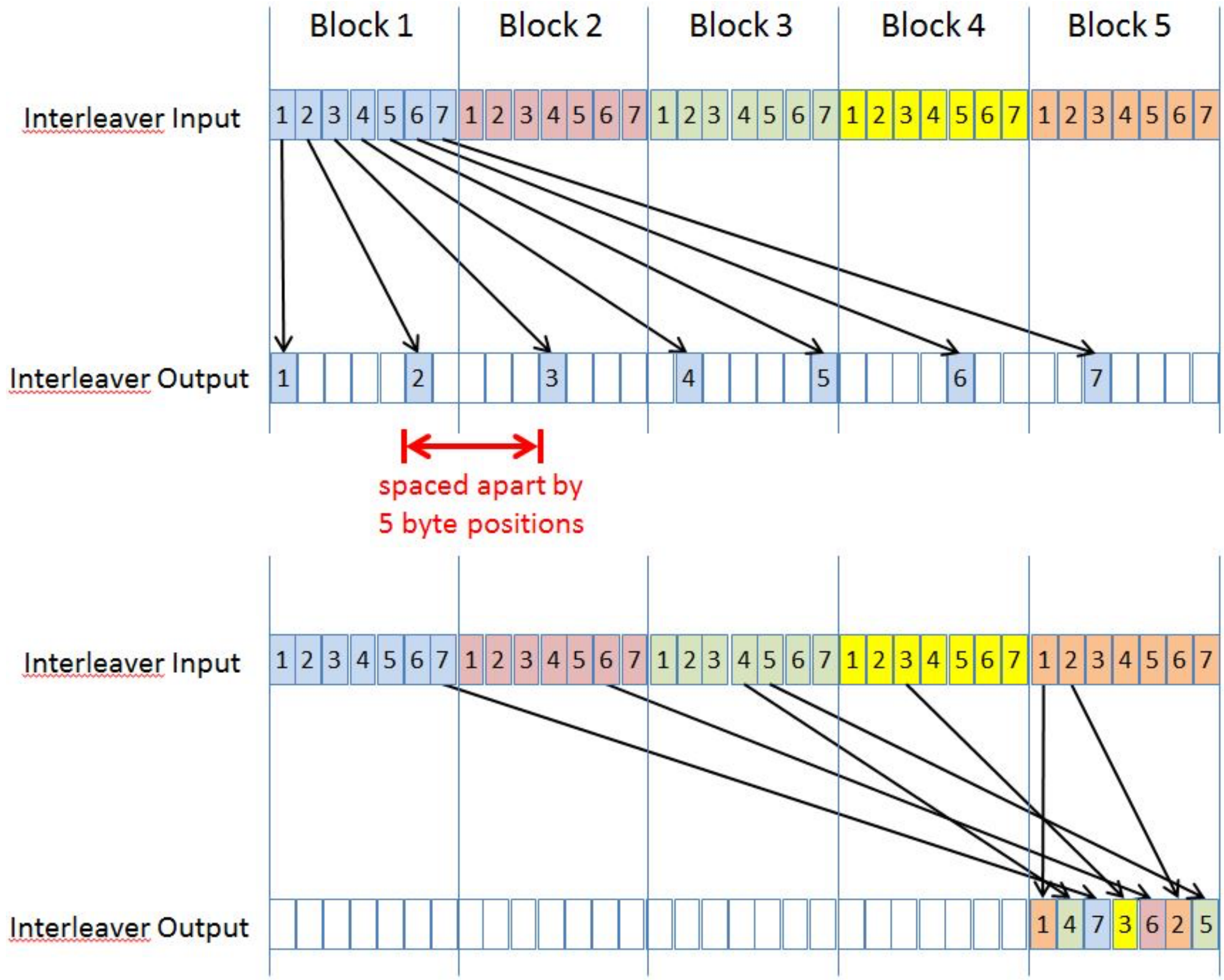


Figure 2: Convolutional interleaver with I = 7 and D = 5.

90. In a DSL transmitter, the interleaver operation follows the FEC encoding operation, *i.e.*, the interleaver's input consists of FEC output codewords. *See, e.g.,* TQD043494- TQD043495 (G.992.3 at pp. 39 and 40); TQD078461 (G.993.1 at p. 14). For some DSL standards, the input block size of the interleaver may be equal to the FEC output codeword size. *See* TQD043494-TQD043495 (G.992.3 at pp. 39 and 40). In other DSL standards, the FEC output codeword size can be an integer multiple of the interleaver input block size. *See, e.g.*, TQD078462 (G.993.1 at p.15) (describing "[t]he block length I shall divide the RS codeword length N (i.e., N shall be an integer multiple of I)").

B. THE FAMILY 6 PATENTS

91. The ’835 patent provide a novel solution that improves DSL performance and reliability by adapting impulse noise protection to changing conditions while continuing to communicate data. *See* ’835 patent (TQD071718 – TQD071738) at 1:20–25, 8:4–9:18, and Figures 1, 3, 4 and 6.

92. The ’835 patent explains that, at the time of the inventions, it was standard practice for DSL systems to use interleaving in conjunction with FEC coding to counter the effects of impulse noise. *See* ’835 patent at 1:27–37 (stating “[i]t is standard practice for communications systems to use interleaving in combination with Forward Error Correction (FEC) to correct the errors caused by impulse noise”). DSL systems implementing the ADSL2 (G.992.3) standard, were an example of such systems. Figure 7-6 of G.993.2 (reproduced below) illustrates an example DSL transmitter employing FEC and interleaving.

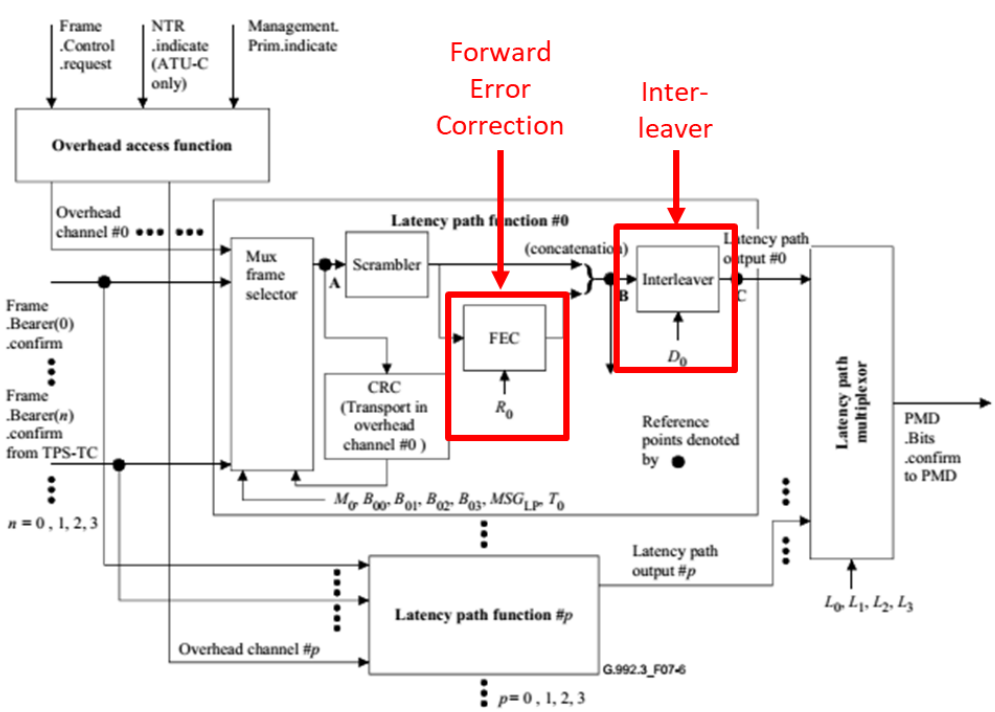


Figure 7-6/G.992.3 – Block diagram of transmit PMS-TC function

G.992.3 § 7.4, p. 27-28), Fig. 7-6. A corresponding receiver would include a de-interleaver followed by an FEC decoder. *See* ’835 patent at 8:8–17.

93. FEC and interleaving parameters include the FEC codeword size, the FEC input block length, the number of added FEC redundancy bytes, and the interleaver depth D. See ’835 patent at 2:22–25, TQD043494-TQD043495 (G.992.3 at pp. 39-40). The ’835 patent refers to FEC and Interleaving Parameters by the acronym “FIP.” See ’835 patent at 2:22–25.

94. The ’835 patent describes a problem wherein DSL systems do not properly characterize impulse noise and therefore may choose FIP parameters that result in an unacceptably high bit error rate. *See id.* at 1:45–62. Various possible solutions to address this problem had problems of their own. For example, one possible solution is to reinitialize the DSL transceiver in an attempt to arrive at more appropriate FIP parameters. But this requires disabling the communication link for an unacceptably long period of time. Another possible solution is to initially chose FIP values that provide more impulse noise protection than needed at the time of initialization. But this solution results in a connection with higher latency (i.e., longer delay) than needed. *See* ’835 patent at 2:22–3:16.

95. The inventions of the ’835 patent improve a DSL system’s ability to deliver a sufficiently low bit error rate in the presence of impulse noise without compromising high data rate or adding more latency (delay) than necessary. The inventions also substantially reduce the need for repeated and lengthy re-initialization procedures that interrupt steady-state data transmission (*i.e.*, “Showtime”). *Id.* The ’835 patent explains that:

> In accordance with one particular aspect of this invention, the system can transition from one FIP setting to another FIP setting without going through the startup initialization procedure such as the startup initialization sequence utilized in traditional xDSL systems. For example, an xDSL system that implements the systems and methods described herein could start using an FIP setting of (N=255,

> K=247, R=8, D=64) and then transition to an FIP setting of (N=255, K=239, R=16, D=64) without re-executing the startup initialization procedure.

’835 patent at 3:37–47.

96. An example of updating FIPs during Showtime is described with respect to Figures 3 and 6 of the ’835 patent:

> FIG. 3 outlines an exemplary method for performing impulse noise protection adaptation during Showtime according to this invention. In particular, control begins in step S300 and continues to step S310. In step S310, traditional DSL initialization occurs. Next, in step S320, Showtime is entered between the two modems using the first FIP setting that was determined during the initialization in step S310. Then, in step S330, a determination is made whether bit errors are occurring using the first FIP setting. If bit errors are not occurring, control continues to step S340 where the control sequence ends. Otherwise, control jumps to step S350.
>
> In step S350, a determination is made that an increase of the INP setting is required that requires modification of the FIP parameters. Next, in step S360, updated INP parameter is determined and a message forwarded to the receiver specifying the new INP setting. Then, in step S370, the receiver forwards to the transmitter updated FIP parameters for the new impulse noise protection requirements. Control then continues to step S380.
>
> In step S380, the transmitter and receiver transition to using the updated INP parameters at a synchronization point. Next, in step S390 Showtime operation continues. Control then continues back to step S330.

’835 patent at 18:3–26, and Fig. 3.

> FIG. 6 illustrates an exemplary method of synchronization using a flag signal according to this invention. In particular, control begins in step S600 and continues to step S610. In step S610, the modems enter Showtime using the first FIP parameters. Next, in step S620, a message is exchanged indicating the new FIP settings. Then, in step S630, the transmitter forwards to the receiver a flag signal indicating when the new FIP settings are to be used.
>
> At step S640, and at a predefined change time following the transmission of the flag signal, the transmitter begins transmission using the new FIP parameters. Next, at step S650, at the predefined change time following the reception of the flag signal, the receiver commences reception utilizing the new FIP parameters. Control then continues to step S660 where Showtime communication continues with the control sequence ending at step S670.

’835 patent at 19:15–30, and Fig. 6.

97. Examples described in the '835 patent use a flag signal to synchronize the transition from one set of FIP parameter values (i.e., a first FIP setting) to another set of FIP parameter values (i.e., a second FIP setting). A flag signal is sent from a receiving transceiver to a transmitting transceiver to synchronize when the transition to new (second) FIP setting is to occur. *Id.* At a predefined change time, following the transmission of the flag signal, the transmitter begins transmission using the new (second) FIP setting. *Id.* In one example of "synchronization using a flag signal, the receiver and transmitter would start using updated FEC and interleaving parameters on a pre-defined FEC codeword boundary following the sync flag." '835 Patent at 12:8–11.

I declare under penalty of perjury that the above is true and correct, to the best of my knowledge. Executed on this ___ day of March 2022, in Johns Creek, GA.

Vijay K Madisetti

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